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Final Report

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FINAL REPORT

Project Title: **Ammoniated Flax and Wheat Residues as Winter Feed for Beef Cows**

Originating Units: Flaxgrowers Western Canada;
Department of Animal & Poultry Science,
College of Agriculture,University of Saskatchewan and
Saskatchewan Research Council.

Location: Termuende Research Station, Lanigan and
University of Saskatchewan,Saskatoon

Project Leaders: R.D.H. Cohen, (Research), Department of Animal & Poultry Science,
University of Saskatchewan, S7N 0W0. (Ph: (306)-966-4134)
J.A. Kernan, (Research), Saskatchewan Research Council
M.E. Mann (Graduate Student-Research),
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ABSTRACT:

The effect of ammoniation of flax, lentil and wheat straws and wheat chaff at 3.5% (w/w) of dry matter on digestibility, crude protein content and production when fed to over-wintering beef cows was studied.

Ammoniation increased CP two-fold and *in vitro* OMD from 35.2%, 36.3% and 41.0% to 46.3%, 46.5% and 42.6% for flax straw, wheat chaff and wheat straw and from 35.3%, 45.1%, 37.4% and 30.1% to 40.7%, 47.9%, 44.7% and 38.2% for flax straw, lentil straw, wheat chaff and wheat straw in Years 1 and 2 respectively. Ammoniated crop residues plus ground barley were adequate substitutes to hay in maintenance rations.

SUMMARY

AMMONIATING FLAX STRAW, LENTIL STRAW AND WHEAT CHAFF

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In the past, straw and chaff have simply been low quality crop residues. More recently it has been shown that ammoniating cereal straws can increase the crude protein level 2 to 3 times the original level and improve digestibility by 10-15%. In addition, improved digestibility and palatability increase intake 10-20%.

Research conducted at the University of Saskatchewan's Termuende Research Station and funded by the Flaxgrowers Western Canada (ERDA Project 2.2-9) shows that similar improvements can be obtained when ammoniating flax straw, lentil straw and wheat chaff (Table 1). An additional benefit of chaff collection is the fact that small seeds and cracked grain are removed with the chaff during combining which reduces volunteer growth of grains and weeds.

Application of anhydrous ammonia (NH_3) to stacked roughage should take place when feed has a minimum moisture content of 12-15% and temperature is 5°C or higher. For example, the morning of an early fall day after a heavy dew.

Each stack should be downwind from farm buildings and cattle facilities. Stacks should be covered with 6mm weight plastic sheets (100 x 40 ft), then ammoniated with 3.5% NH_3 on a dry matter basis. When covering a stack, a two foot overlap should be secured to the ground around the entire stack in order to seal it. Forage should be exposed to ammonia for 21 days or longer for the reaction to take place. Details on ammoniation procedures are available from your Ag Rep. and most anhydrous ammonia suppliers.

When feeding ammoniated crop residues, stacks should be uncovered and allowed to air for 1-2 days

Table 1. Effect of Ammoniating Flax Straw, Lentil Straw, Wheat Straw and Wheat Chaff on Feed Quality: Average of 1985-86 and 1986-87 data

	% Crude Protein	% Dry Matter Digestibility	% Increased Intake
Flax	3.4	31	21-67
NH_3 Flax	8.6	51	
Lentil *	6.6	45	24
NH_3 Lentil	17.1	53	
Wheat	4.4	38	0-58
NH3 Wheat	8.4	49	
Chaff	6.4	41	7.6-33
NH_3 Chaff	12.8	51	

*: 1986-87 data only

Table 2. Dry matter intake, estimated TDN intake and average daily gain (ADG) of cows fed ammoniated crop residues, 1986-87 (lb per day).

	NH_3 Flax Straw	Lentil Straw	NH_3 Lentil Straw	Wheat Chaff	NH_3 Wheat Chaff	NH_3 Wheat Chaff	Hay
			Mature Cows				
Forage	14	20	22	20	19	20	19
Barley	5.0	3.5	3.5	3.5	3.5	5.0	0.0
TDN Intake	7.5	11.0	13.7	10.6	9.5	11.0	11.0
Gain	0.3	1.4	0.9	0.2	0.5	0.4	0.3
			Second Calf Heifers				
Forage	11	18	22	19	19	21	21
Barley	5.0	3.5	3.5	3.5	3.5	5.0	0.0
TDN Intake	6.6	10.4	13.7	10.4	9.7	11.2	11.7
Gain	0.8	1.3	1.5	0.9	1.0	1.3	1.6

before use. This will reduce the ammonia smell, which may make cattle refuse the feed.

For cows in average condition in the fall, a target average daily gain of 1.0 kg (2.5 lb) for younger cows and 0.5 kg (1.0 lb) for mature cows is needed to help ensure normal birth weight and vigor in calves and maintain good condition of cows. Nutrient allowance recommendations for Saskatchewan indicate 9-10 kg (20-22 lb) (as fed basis) of daily feed for beef cows containing 4.5-7 kg (10-14 lb) TDN. Since the cow will normally eat only 6-7 kg (13-15 lb) of straw (Table 2) an additional 1.8-3.6 kg (4-8 lb) of grain or high quality hay is also required. In addition, salt, mineral and Vitamin A are necessary for optimum performance of the beef cow herd.

It is important to have ammoniated feeds analyzed for quality when incorporating them in a winter feeding program. This is because the quality of crop residues is dependent on many factors such as growing and harvesting conditions, moisture content, temperature during treatment and type of crop residue. Consequently, the quality of ammoniated feeds can be highly variable. Feed analysis will ensure that adequate and economical grain supplementation will be provided to meet your cows maintenance requirements.

TECHNICAL REPORT

Background and Objectives:

Large amounts of crop residues are available for livestock feeding in western Canada each year. For example, in 1985 and 1986 an estimated 24.8 and 22.6 million tonnes of cereal crop residue respectively (constituting 1/3 of the total straw and all the chaff production) were removable from prairie fields without detriment to soil tilth in 1985 and 1986 (Table 1).

Table 1. Estimated crop residues of selected field crops available for livestock feeding in western Canada, 1985-86 (10^6 t)

Field Crop	Residues Available for Livestock Feeding 1985	1986
cereal straw	22.4	16.0
cereal chaff	2.4	6.6
lentil straw	-.-	0.4
flax straw	2.9	3.0
TOTAL	27.7	26.0

Crop residues are considered low in feeding value because of their low digestibility. It has been well established that chemical treatment such as ammoniation will increase the feeding value of cereal straws. However, little information is available on the feeding value of other crop residues commonly produced in western Canada and the effect of chemical treatments on these residues. Though not available on such a massive scale as cereal residues, these non-cereal crops also produce large amounts of fibrous byproduct (Table 1) with potential value as ruminant feed. These residues may be particularly abundant in localities where these crops are most commonly grown.

Flax straw degrades slowly and must be removed from the land and disposed of by some means, usually by burning. It has also been commonly accepted that flax straw was not suitable as feed for ruminants. Information from some producers had indicated, however, that ammoniated flax straw may be suitable for incorporation into maintenance rations for pregnant beef cows.

On farm demonstration trials indicate that ammoniated wheat chaff would likely make a suitable and inexpensive maintenance ration if supplemented with vitamins and minerals. This potential feedstuff is higher in feeding value than straw because it contains seed head parts and broken grain. In using chaff as a feedstuff the farmer also benefits from the removal of weed seeds and anti-germination factors from the field. However, the majority of this feedstuff remains on the fields.

In the second year of research, the feeding value of lentil straw and ammoniated lentil straw was investigated. This feedstuff was added to the trial because of the increasing importance of lentils in the Saskatchewan farm economy and the lack of information on the feeding value of lentil straw.

More information on these potential ration ingredients is required to assess their feed value compared to that of more conventional rations. Three such crop residues, flax straw, wheat chaff and lentil straw were studied during two years of research financed with $70, 400 through the Canada/Saskatchewan Economic and Regional Development Agreement (ERDA) Project 2.2-9.

Feeding value of these crop residues was assessed by:

1) determining the *in vitro* and *in vivo* digestible organic matter content (DOM%) and voluntary intake of plain and ammoniated flax straw, wheat straw, wheat chaff and lentil straw in comparison to bromegrass/alfalfa hay.

2) evaluating ammoniated flax straw, ammoniated wheat straw, wheat chaff, ammoniated wheat chaff, lentil straw and ammoniated lentil straw in comparison to brome/alfalfa hay as feedstuffs for non-lactating, gestating beef cows during winter.

Experimental Methods:

Ammoniation of crop residues:

The crop residues and hay were collected within a 5 mile radius of the Termuende Research Station, Lanigan, Saskatchewan. Wheat, flax and lentil straws and wheat chaff were stacked, covered with 8 mil black plastic and treated with anhydrous ammonia (NH_3 gaseous) at the rate of 3.5% (w/w) of feed dry matter.

The moisture content of the flax straw, wheat straw and wheat chaff determined from pretreatment samples was 17%, 15% and 15% respectively in 1985 and 16%, 19% and 16% respectively in 1986. The moisture content of lentil straw in 1986 was 16%. A minimum moisture content of 15% was obtained in the chaff by wetting and turning with a front end loader and in the straw by baling early in the morning.

The crop residues were allowed to cure 21 days in 1985 (Oct. 25-Nov 15) and 30 days in 1986 (Oct 14-Nov. 12) before the stacks were opened and the plastic removed. The feedstuffs were then allowed to aerate a further 24 hours before sampling took place and feeding began.

Chemical analysis, voluntary intake and digestibility:

Composite samples were obtained from each feedstuff before and after ammoniation for chemical analysis. Total nitrogen was determined using the Kjeldahl method and percent crude protein was calculated. *In vitro* digestible organic matter (DOM) was determined using the Tilley and Terry method.

In each year, Hereford or Hereford-Simmental steers were used to determine the *in vivo* digestibility and voluntary intake of the crop residues. Four steers were randomly assigned to each of three treatments. A 7-10 day adjustment period was followed by a 7 day voluntary intake measurement period then a 5 day total faecal collection period during which

feed intake was reduced to 80% of voluntary intake. Steers were reassigned to new treatments until the *in vivo* digestibility of each feed had been determined.

Digestibility of crop residues were determined indirectly using a basal ration. In 1985-86, the *in vivo* DOM of ammoniated and non-ammoniated flax straw and wheat straw were determined using 2 kg of clover hay (58.2% *in vivo* DOM) and 1 kg of dairy concentrate (69.6% *in vivo* DOM) as the basal diet, while only 1 kg of dairy concentrate was used for the wheat chaff. In 1986-87 each of the rations was supplemented with 1 kg alfalfa pellets (63.3% *in vivo* DOM). Digestibility of the brome/alfalfa hay was determined directly.

Acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL) were determined on both feed and faecal samples obtained during the total collection period and digestibility coefficients were calculated.

Winter feeding trial:

110 cows in 1985-86 and 232 cows in 1986-87, held outdoors in open pens with wind protection provided by porosity fences, were used in a winter feeding trial. They were separated into mature (3 or more gestations) and young (2nd gestation) cow age groups and then randomly assigned to treatments.

Treatments consisted of rations based on ammoniated flax straw, ammoniated wheat straw, wheat chaff and ammoniated wheat chaff with the addition of lentil straw and ammoniated lentil straw in the second year of the trial. Bromegrass/alfalfa hay was fed alone to mature and younger cows as a control treatment.

Crop residue rations were supplemented with barley to meet NRC requirements and to be equivalent in TDN to the brome/alfalfa hay control ration. In the first year of the trial the feeding value of the ammoniated crop residues was unknown and assumed to be very low. Consequently the residue rations were supplemented with excessively high levels of barley. In 1986-87 the barley supplementation was reduced to a level more in keeping with requirements of a beef cow winter maintenance program.

In 1985-86 the crop residues were fed according to appetite. If the feeding allowance was not consumed in one-day, the next feeding was skipped. In 1986-87, crop residues were limited to 11 kg per day of dry matter. Barley was fed on a daily basis. Feed intake per pen was recorded daily. Trace-mineralized salt was provided free choice. Cows were injected monthly with 5 ml vitamin A (500,000 IU/ml), vitamin E (50 IU/ml) and vitamin D_3 (75,000 IU/ml).

All cows in each year of the trial were weighed at the beginning of the trial and every 28 days. Backfat was measured monthly in the younger cows in 1985-86 and in both age groups in 1986-87.

The trial ran from November 15, 1985 to March 7, 1986 and from November 13, 1986 to February 3, 1987.

Results and Discussion:

Chemical analysis, voluntary intake and digestibility

In each year of the trial, crude protein content increased approximately two-fold after treatment with anhydrous ammonia for each crop residue studied (Table 2) . This is in keeping with the majority of studies reported in the scientific literature which indicate that increases of 5 to 6 percentage units in crude protein content is expected with ammoniation. The fibre (ADF, NDF) and lignin (ADL) levels of crop residues are unchanged by ammoniation and any differences are indicative of sample variability.

Ammoniation is expected to increase the digestibility of low quality feedstuffs by swelling the fibre and, to a certain extent, by solubilizing the indigestible chemical linkages between lignin and hemi-cellulose. In this way fibre is more accessible to rumen micro-organisms. In addition, voluntary intake is increased due to increased digestibility and palatability. Thus more available nutrients are presented to the digestive tract.

Ammoniation increased the *in vitro* and *in vivo* OMD of flax straw 31.5% and 72.3% respectively in Year 1 of the digestibility trial (Table 3). Increased digestibility of the flax straw was a result of enhanced digestibility of the ADF (ADF-D) and NDF (NDF-D) fractions of fibre. In addition, voluntary intake of flax straw dry matter increased 40%, from 4.7 kg and 7.9 kg, with ammoniation (Table 4).

In Year 2 *in vitro* and *in vivo* OMD of flax straw was increased only 15.3% and 1.6% respectively (Table 3). Voluntary dry matter intake of flax straw in the digestibility trial in Year 2 was less than 1% of body weight (Table 4) probably due to an inadequate adjustment period. Consequently, rate of passage may have been reduced and *in vivo* OMD enhanced for both plain and ammoniated flax straw thus masking any effects on digestibility due to ammoniation.

Table 2. Chemical composition of treated and untreated crop residues and brome-alfalfa hay (%)

	1985-86				1986-87			
	CP	ADF	NDF	ADL	CP	ADF	NDF	ADL
Flax straw	2.8	58.7	73.8	10.6	4.0	59.1	76.6	12.8
NH_3 Flax straw	8.1	57.4	71.9	10.5	9.0	62.2	80.4	14.6
lentil straw	-.-	-.-	-.-	-.-	6.6	41.8	64.0	9.4
NH_3 lentil straw	-.-	-.-	-.-	-.-	17.1	36.4	56.5	7.9
wheat chaff	5.7	48.3	77.0	6.6	7.1	48.2	71.8	6.3
NH_3 wheat chaff	12.1	45.6	72.0	5.6	13.5	52.1	73.1	6.5
wheat straw	3.1	42.6	65.4	6.8	5.7	51.8	78.8	6.8
NH_3 wheat straw	6.5	50.3	74.7	7.0	10.3	52.1	72.1	6.9
brome/alfalfa hay	14.3	28.2	48.2	4.2	17.4	30.6	54.5	5.3

Table 3. Effect of ammoniation on crop residue *in vitro* and *in vivo* OMD and digestibility of ADF and NDF (%) compared with brome/alfalfa hay

	flax straw	NH_3 flax straw	lentil straw	NH_3 lentil straw	wheat chaff	NH_3 wheat chaff	wheat straw	NH_3 wheat straw	brome alfalfa hay
				1985-86					
in vitro OMD	35.2	46.3	-.-	-.-	36.3	46.5	41.0	42.6	62.8
in vivo OMD	33.9^{b}	58.4^{cd}	-.-	-.-	55.3^{c}	63.4^{d}	42.6^{c}	41.7^{a}	62.0^{cd}
ADF-D	9.9^{a}	43.9^{b}	-.-	-.-	42.0^{b}	50.7^{b}	8.7^{a}	15.3^{a}	43.1^{b}
NDF-D	-0.6^{a}	37.9^{b}	-.-	-.-	46.3^{bc}	56.6^{c}	9.1^{a}	18.4^{a}	50.2^{bc}
				1986-87					
in vitro OMD	35.3	40.7	45.1	47.9	37.4	44.7	30.1	38.2	55.9
in vivo OMD	64.2^{a}	65.2^{a}	44.5^{cd}	51.6^{bc}	37.8^{d}	49.0^{c}	45.0^{d}	51.0^{bc}	61.7^{ab}
ADF-D	24.6^{c}	33.2^{bc}	33.5^{bc}	35.6^{abc}	24.6^{c}	41.8^{ab}	36.7^{abc}	50.3^{a}	45.2^{ab}
NDF-D	62.8^{ab}	68.3^{a}	44.9^{de}	48.1^{cde}	34.9^{fe}	50.3^{bcde}	45.5^{cde}	56.6^{abcd}	57.3^{abc}

a-g: unlike superscripts indicate significant differences within the row ($P<0.05$).

However, the increase of 15.3% in *in vitro* OMD indicates that some effect of ammoniation is still taking place. It should be noted that the effect of ammoniation on crop residues is dependent on many variables which are often less than optimum at the time of ammoniation. Crop variety, time of harvest, temperature, length of treatment time and residue moisture content are all factors affecting the ammoniation process. The difference in the reaction of flax straw to ammoniation from Year 1 to Year 2 could be due to any one of these factors but most probably initial moisture content was the most important factor.

Lentil straw did not improve greatly with ammoniation. *In vivo* OMD increased 15% with ammoniation and *in vitro* OMD increased 6% (Table 3). However, voluntary dry matter intake increased 25% (Table 4). Differences in fibre digestibility after ammoniation may be due to differences in fibre chemistry between legumes and non-legumes. The scientific literature indicates that chemical linkages between lignin and hemi-cellulose in legumes are less susceptible to alkali degradation than in grasses.

Wheat chaff showed consistently good improvement with ammoniation. On average, for the two years of the trial, *in vitro* OMD increased 22.2%, *in vivo* OMD increased 18.8%, ADF-D increased 30.9%, NDF-D increased 31.1% (Table 3) and voluntary intake

Table 4. Voluntary intake of dry matter of plain and ammoniated crop residues

	1985-86		1986-87	
Feedstuff	kg	%bwt	kg	%bwt
flax straw	4.69	1.95	2.82	0.76
NH_3flax straw	7.86	3.28	3.43	0.88
lentil straw	-.-	-.-	4.53	1.69
NH_3 lentil straw	-.-	-.-	5.63	1.87
wheat chaff	8.86	3.50	5.25	1.92
NH_3 wheat chaff	11.81	4.67	5.65	2.01
wheat straw	5.78	2.40	3.15	1.15
NH_3 wheat straw	5.34	2.22	5.00	1.71
brome-alfalfa hay	13.96	5.67	7.55	2.68

increased 20.5% (Table 4). This consistency is probably the result of initially higher and more evenly distributed moisture content due to premoistening as compared with the straw residue.

Wheat straw did not react well to ammoniation in Year 1 but reacted well in Year 2 of the trial. Differences in the ammoniation effects between years is probably due to low initial moisture content in Year 1 of the trial. Pre-treatment sampling indicated that moisture content of the straw in Year 1 was 16%; adequate for ammoniation. However, variability in moisture content throughout the stack could result in an overall low moisture content. The differences in feed value between Year 1 and Year 2 illustrate the variability that can occur in the effects of ammoniation. *In vitro* OMD increased 3.9% in Year 1 versus 26.9% in Year 2; *in vivo* OMD did not improve in Year 1 versus 27.5% in Year 2 (Table 3) and voluntary intake decreased 7.6% in Year 1 versus increasing 58.7% in Year 2.

Winter feeding trial:

The Termuende cow herd was wintered successfully on the crop residue rations for two consecutive years. In Year 1 of the trial, the intake of the crop residue portion of the rations was greatest for those cows fed ammoniated chaff followed, in order, by those cows fed chaff, ammoniated flax straw and ammoniated wheat straw (Table 6).

Cows fed the hay ration had the highest daily gain followed, in order, by those cows fed ammoniated flax straw, ammoniated chaff and ammoniated wheat straw and chaff. This trend is the same in both mature and young cows (Table 5). Weight gains were high averaging 0.78 kg per day and 0.85 kg per day for mature and young cows respectively. Similarly, the increases in backfat thickness in the young cows was greatest for those cows fed hay and ammoniated flax straw followed, in order, by ammoniated chaff, ammoniated wheat straw and chaff rations (Table 5). The trends in weight gain can largely be explained by the estimated TDN intake for each of the rations (Table 6).

Table 5. Average daily gain (kg) and change in backfat thickness (mm) of cows fed ammoniated crop residues

	NH_3 flax straw	lentil straw	NH_3 lentil straw	wheat chaff	NH_3 wheat chaff	NH_3 wheat straw	Brome-alfalfa hay
			1985-86				
Average Daily Gain:							
Mature Cows	$.91^{b}$	-.-	-.-	$.55^{d}$	$.71^{c}$	$.56^{d}$	1.18^{a}
Young Cows	$.97^{b}$	-.-	-.-	$.68^{d}$	$.76^{c}$	$.70^{d}$	1.16^{a}
Change in Backfat:							
Young Cows	4.0^{a}	-.-	-.-	0.0^{c}	2.13^{b}	1.88^{b}	4.0^{a}
			1986-87				
Average Daily Gain:							
Mature Cows	$.14^{c}$	$.63^{a}$	$.40^{b}$	$.06^{c}$	$.23^{b}$	$.19^{c}$	$.12^{c}$
Young Cows	$.36^{c}$	$.61^{a}$	$.69^{ab}$	$.42^{c}$	$.45^{bc}$	$.57^{a}$	$.71^{a}$
Change in Backfat:							
Mature Cows	-0.7^{a}	2.3^{a}	-0.2^{a}	-0.8^{a}	1.2^{a}	-1.2^{a}	-0.8^{a}
Young Cows	-1.0^{a}	0.9^{a}	1.0^{a}	-0.3^{a}	1.9^{a}	0.0^{a}	2.4^{a}

a-d: unlike superscripts indicate significant differences within a row ($P<0.05$)

The large amount of barley fed undoubtedly contributed to the large weight gains in the cows. Interpretation of the effect of ammoniation on the crop residues in the wintering experiment is difficult because of the barley supplementation. However, results from the steer digestibility trial show that ammoniation increased the organic matter digestibility (Table 3) and feed intake of the flax straw (table 4) and wheat chaff suggesting the responses in the cow feeding trial were at least in part due to ammoniation.

In Year 2 of the trial, barley intake was reduced (Table 7) and crop residue dry matter intake was limited to 11 kg per day. Crop residue dry matter intake by the mature cows was greatest for NH_3 lentil straw followed, in order, by cows fed lentil straw, chaff, ammoniated wheat straw, ammoniated chaff and ammoniated flax straw . In young cows the order of dry matter intake was ammoniated lentil straw, ammoniated wheat straw, chaff, ammoniated chaff, lentil straw and ammoniated flax straw.

Mature cows fed lentil straw had the highest gain followed, in order, by cows fed ammoniated lentil straw, ammoniated wheat chaff, ammoniated wheat straw, ammoniated flax straw, hay and wheat chaff. Gain on the ammoniated lentil straw ration may have been reduced as a result of contamination of the straw with Russian thistle thus limiting intake to below that estimated. In the young cows the greatest gain was produced by the hay ration followed by ammoniated lentil straw, lentil straw, ammoniated wheat straw , ammoniated wheat chaff, wheat chaff and ammoniated flax straw.

Table 6. Dry matter intake and estimated TDN intake (kg d^{-1}) of cows fed various crop residues and bromegrass/alfalfa hay, 1985-86

	NH_3 flax straw	lentil straw	NH_3 lentil straw	wheat chaff	NH_3 wheat chaff	NH_3 wheat straw	brome alfalfa hay
Mature Cows:							
Roughage	4.6	-.-	-.-	5.7	7.8	3.8	11.3
Barley	5.6	-.-	-.-	3.0	2.4	4.3	0.0
Estimated TDN	5.7	-.-	-.-	4.5	5.3	4.6	5.8
Young Cows:							
Roughage	3.2	-.-	-.-	4.7	10.0	3.0	9.0
Barley	5.6	-.-	-.-	3.2	2.3	4.5	0.0
Estimated TDN	5.2	-.-	-.-	4.3	6.2	4.9	4.6

Again, trends in average daily gain in Year 2 of the trial are closely associated with estimated TDN intake (Table 7). The exception is the ammoniated wheat chaff ration which produced gains greater than expected on the basis of estimated TDN intake. This may indicate higher energy content, possibly from broken grain, in the chaff than suggested by chemical analysis of a sample.

In both mature and young cows, higher intake of ammoniated flax straw but decreased grain supplementation resulted in lower average daily gain than in Year 1 of the trial. Though flax straw intake was increased, reduced improvement in *in vitro* DOM in Year 2 (Table 3) indicate that ammoniation was somewhat less effective. The reason for low gain of mature cows on the hay ration is unknown.

Backfat thickness remained largely unchanged during Year 2 with the exception of ammoniated wheat chaff which produced an increase in backfat greater than would be expected from relative TDN intake.

Table 7. Dry matter intake and estimated TDN intake (kg d^{-1}) of cows fed various crop residues and bromegrass/alfalfa hay, 1986-87

	NH_3 flax straw	lentil straw	NH_3 lentil straw	wheat chaff	NH_3 wheat chaff	NH_3 wheat straw	brome alfalfa hay
Mature Cows:							
Roughage	6.8	9.2	9.8	9.1	8.6	9.0	9.1
Barley	2.4	1.7	1.7	1.7	1.7	2.4	0.0
Estimated TDN	3.4	5.0	6.2	4.8	4.3	5.0	5.0
Young Cows:							
Roughage	5.0	8.3	9.8	8.8	8.8	9.5	9.7
Barley	2.4	1.7	1.7	1.7	1.7	2.4	0.0
Estimated TDN	3.0	4.7	6.2	4.7	4.4	5.1	5.3

Over all treatments in Year 2 , average daily gain was .53 kg per day and .31 kg per day less for mature and young cows than in Year 1 while change in backfat thickness was 1.7 mm less for young cows. The average daily gain of .55 kg per day for mature cows and .54 kg per day for young cows in Year 2 was more than adequate for the excellent fall condition of the Termuende herd. However, for the average fall condition of the Saskatchewan cow herd, a target average daily gain of 1 kg for young cows and 0.5 kg for mature cows is needed to ensure normal birth weight and vigor in calves and body condition in cows.

The large variability in gain and effect on backfat thickness with ammoniation from ration to ration and from year to year in this trial emphasizes the need to have crop residues analyzed by a feed testing laboratory. Feed analysis will ensure adequate and economical grain supplementation to meet maintenance requirements.

Conclusions and Impact:

These studies indicate that ammoniated flax straw, lentil straw, ammoniated lentil straw, wheat chaff, ammoniated wheat chaff and ammoniated wheat straw, when supplemented with barley, are adequate alternatives to hay during the winter feeding period of beef cows.

Ammoniation increased *in vitro* and *in vivo* digestibility , crude protein, and intake of ammoniated crop residues to improve their feeding value. Effects of ammoniation were somewhat variable. This variability can be attributed to less than optimum conditions at the time of ammoniation. Therefore, feed analysis should be conducted each year when utilizing ammoniated feedstuffs in order to formulate adequate and economical maintenance rations.

The practical value to the prairie farmer of using ammoniated crop residues is in reduction of costs of maintaining the beef cow herd. Normally, crop residues remain in the field or are disposed of by other methods such as burning of flax straw. Because they are a byproduct of the main grain or oilseed enterprise, crop residues can be obtained for essentially zero cost. Costs incurred in collecting and hauling crop residues are essentially the same as for hay crops. If the cost of ammoniation and supplemental grain are less than the cost of hay in the field then ammoniated crop residues become economical.

This situation may occur when grain prices are low and the grain farmer wishes to diversify his operation with livestock but does not wish to seed or buy hay. One third of the straw and all of the chaff can be removed from the land in most cases without affecting soil tilth. In addition, the removal of weed seeds and anti-germination compounds with chaff may improve future grain yields. In the case of flax straw, ammoniation represents an alternative to burning and may make the crop more appealing to produce, particularly for mixed farmers.

Periodic feed shortages occur in parts of the prairie provinces and use of ammoniated crop residues may be attractive at these times. Improving the feeding value of available crop residues with ammoniation may be more economical than paying the costs of transportation for importing higher quality hay from other parts of the country.

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